

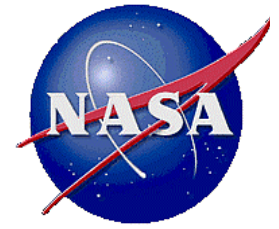
A Tale of Two Failures... the difference between a “Bad Day” and a “Nightmare”

**Leadership ViTS Meeting
5 December 2005**

**James Lloyd, Deputy Chief
Office of Safety and Mission Assurance**

Two similar launch vehicle Accidents...

Two totally different Outcomes

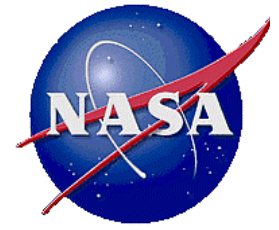


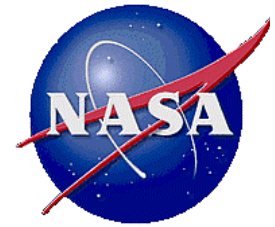
DELTA II 7925
17 January 1997



Chinese Long March CZ-3B
14 February 1996

DELTA II (NAVSTAR GPS IIR-1) 17 January 1997



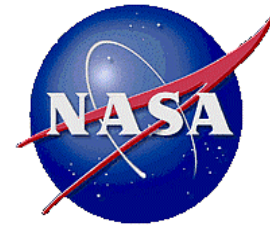


The “Bad Day”

DELTA II 7925, 17 January 1997

- Payload: NAVSTAR GPS IIR-1
- Propellants:
 - Stage 1- LOx/Kerosene main with 9 Graphite Epoxy Motors 40 (GEM 40) solid propellant strap-ons
 - Stage 2 – N_2O_4 /Aerozine 50
 - Stage 3 – Solid propellant
- Initiating event: Accident sequence initiated due to structural failure of one of nine GEMs
- Vehicle stages exploded and/or destroyed by the Flight Termination System within 23 seconds after launch.
- No deaths or injuries
- But property damage (including private automobiles): \$429,000 (trailers and vehicles)
- Root Cause: Investigation inconclusive



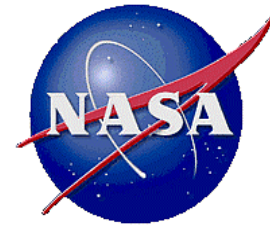


Ultimate control of trajectory and impact

All independent Flight Safety Systems functioned as intended

- 1st Stage Automatic Destruct System triggered by GEM catastrophic failure.
- 2nd and 3rd stages and payload separated largely intact.
- Mission Flight Control Officers sent commands to destroy 2nd and 3rd stages.
- Payload (with station-keeping propellants) exploded on impact.
- Flight Termination System with reliability of 0.999 at 95% confidence level was completely independent of vehicle systems.





Containment of debris

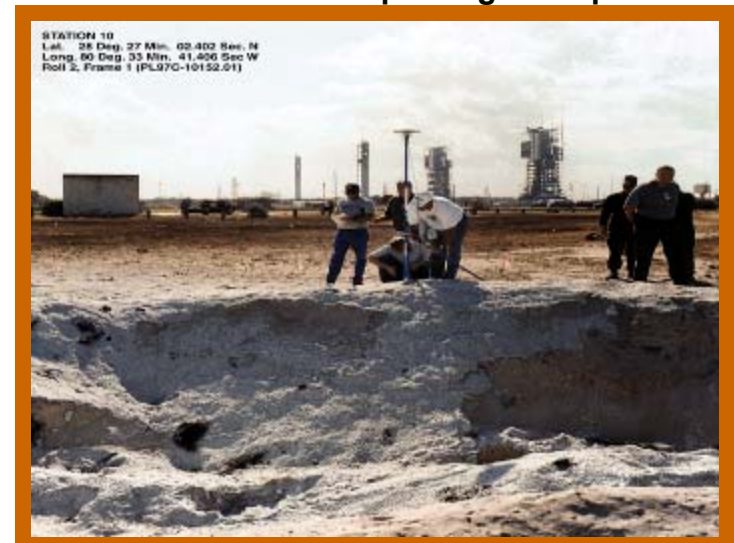
All hazardous debris fell within impact limit lines

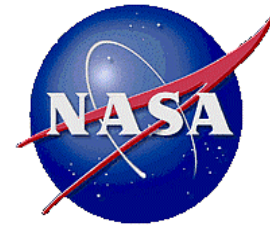
- Range safety organization established:
 - Launch and flight hazard areas.
 - 3-Sigma Debris Impact Limit Lines based on impact dispersion models.
 - Destruct Criteria to contain debris within Impact Limit Lines.
- All designed to control risk to personnel, public, and property from credible debris impacts.

Engine Nozzle



Crater from GEM Exploding on Impact





Protection of worker and public health

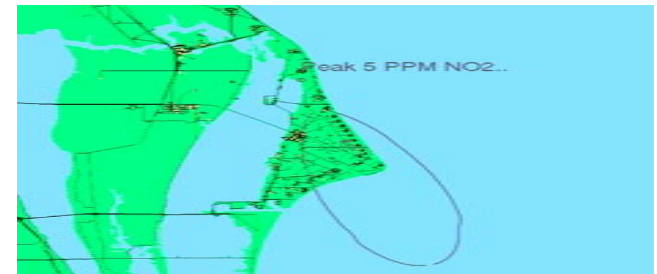
Toxic cloud moved out to sea and dissipated safely at high altitude because Range Safety had established Launch Commit Criteria based on toxic cloud plume models and meteorological conditions at time of launch.

- Criteria designed to control risk of toxic exposure to launch personnel and public from planned toxic releases and releases resulting from credible launch failures.

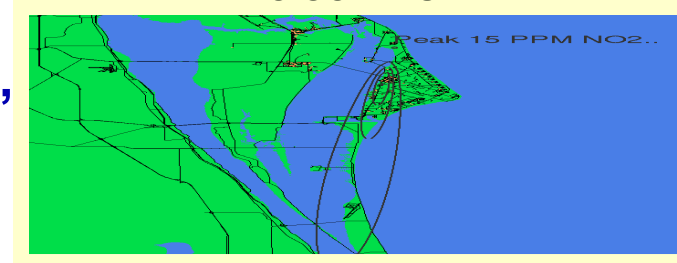
Note: Toxics included hydrogen chloride (HCl), nitrogen dioxide (NO_2), and the various hydrazines.

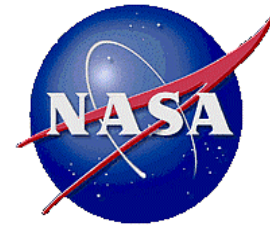


“GO” PLUME



“NO GO” PLUME

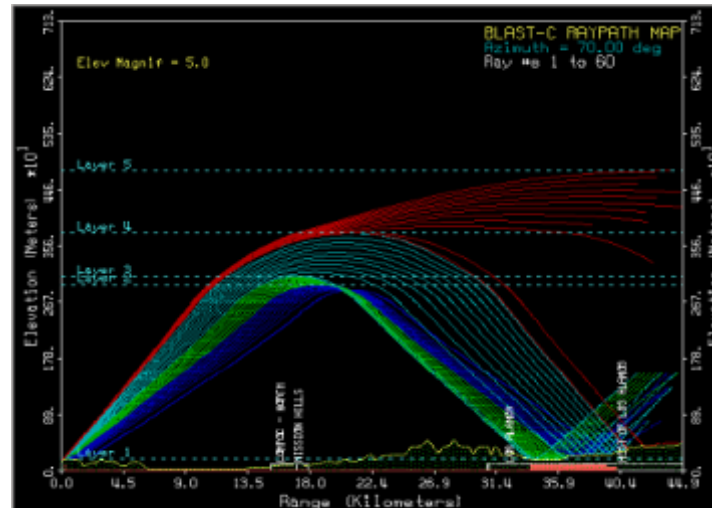




Protection of public property

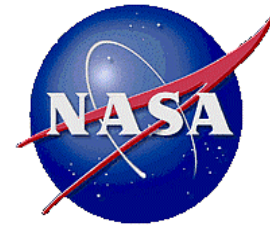
All blast pressure effects were localized, no evidence of long distance blast overpressure focusing

- Safety established **Launch Commit Criteria** based on potential for distance focusing under meteorological conditions at time of launch.
- Criteria designed to control risk to workforce and public from secondary debris from window breakage



**BROKEN WINDOWS
PRESENT
POTENTIAL FOR
SERIOUS INJURIES
DUE TO LONG
DISTANCE BLAST
FOCUSING**

Under Certain Conditions Blast Rays Will Reflect Off an Inversion Layer at Altitude and Focus Back to Ground Level



Protection of launch pad monitors

Earthen berm around blockhouse credited with saving over 70 people from the lethal effects of impact/explosion of a large piece of solid propellant

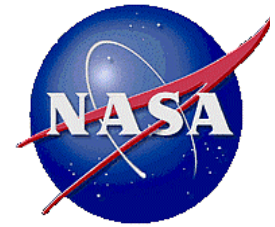
- A 1991 Safety Analysis indicated the blockhouse would not provide adequate protection from potential impact of new, larger solid rocket motors.
- **Safety required buildup of earthen berm and initiated plans for moving mission personnel to “Soft Blockhouse” outside Launch Hazard Area**

(however this accident happened on last launch before planned move to new blockhouse)



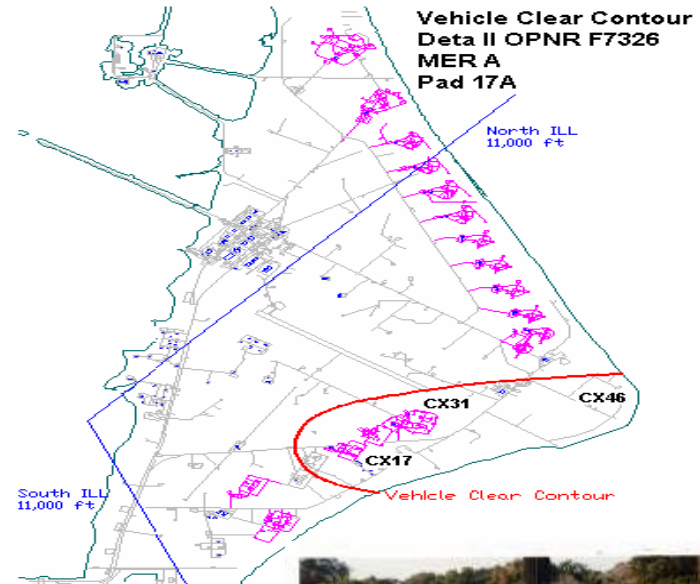
- **Post accident analysis indicated blockhouse would have been penetrated if not for the berm.**

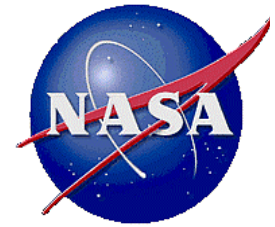
Protection of worker's property



New vehicle parking policy had been promulgated but **Not Enforced**

- Earlier that month, Range Commander signed new policy requiring a vehicle clear zone for each launch.
- Policy was not implemented/enforced for this launch, the result was \$429,000 in losses.
- **Vehicle Clear Zone now enforced for all launches from Cape Canaveral.**

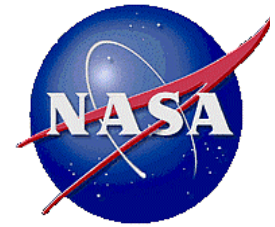




Lessons from Delta II accident experience

- A system for Safety Assurance (independent of mission success) was shown to be effective when conducting the operation having potential for endangering workforce or public.
- Safety systems (physically and operationally independent of vehicle or other mission related systems) are necessary when operating “experimental/developmental” systems with potential to harm the workforce or public.
- Safety analyses must be updated as systems change/evolve and hazard mitigations must be updated accordingly.
- Safety policies and requirements, once established, must be consistently and vigorously enforced.

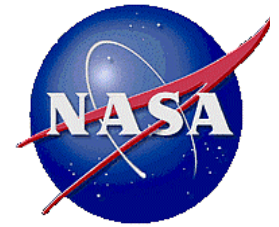
The “Nightmare”



- **Chinese Long March CZ-3B, 14 February 1996**
 - Payload: Intelsat 708
 - Propellants:
 - Stage 1, stage 2 and 4 strap-on rocket motors - $\text{N}_2\text{O}_4/\text{UDMH}$
 - Stage 3 – Liquid O_2/H_2
 - Failure (3rd in 38 months) attributed to guidance system shortcomings (deterioration of gold/aluminum connections in a power amp for the IMU)
 - Vehicle “augured in” nose down at T+22 seconds and exploded violently (20 – 50 tons TNT equivalent)
 - Official Report: six killed and 57 injured in nearby village (Personal accounts indicate over 100 people died)
- **Safety assurance features ???**
 - Conflicting reports whether the vehicle had a Flight Termination System.
 - No analysis of credible failures that would indicate a nearby village in jeopardy.
 - No known safety analysis of potential debris, blast or toxic release.

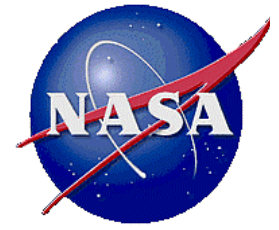


**Only thing worse than a mission failure;
a mission failure that causes workforce
and public casualties.**



Click on the Photo below to run video. [Large file:~30 Meg.]





Epilogue

“It was the best of times, it was the worst of times, it was the age of wisdom, it was the age of foolishness, it was the epoch of belief, it was the epoch of incredulity, it was the season of Light, it was the season of Darkness, it was the spring of hope, it was the winter of despair, we had everything before us, we had nothing before us, we were all going direct to Heaven, we were all going direct the other way - in short, the period was so far like the present period, that some of its noisiest authorities insisted on its being received, for good or for evil, in the superlative degree of comparison only.”

**- Lead paragraph, A Tale of Two Cities,
by Charles Dickens**